

New records of *Crossodactylus schmidtii* Gallardo, 1961 (Anura: Hylodidae) for the state of Rio Grande do Sul, Brazil, with data on morphometry and an updated geographic distribution map

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ABSTRACT: *Crossodactylus schmidtii* Gallardo, 1961 is a diurnal frog inhabiting rocky streams in forested areas, recently considered as a threatened species in the Brazilian states of Rio Grande do Sul and Santa Catarina. Herein we present four new population records of *C. schmidtii* for the northwestern region of Rio Grande do Sul state and discuss the major impacts that may be threatening the species in the state. Additionally, we present an updated map of the current known species distribution and compare morphometric data among populations from Rio Grande do Sul state and Paraná state, in Brazil, and from the province of Misiones, Argentina, based on the examination of voucher specimens available from herpetological collections.

Crossodactylus schmidtii Gallardo, 1961 occurs in northeastern Argentina (Gallardo 1961; Cei 1980), southern Paraguay (Brusquetti and Lavilla 2006), and southern Brazil (Caldart *et al.* 2010; Lucas and Garcia 2011) at elevations of 300-750 m (Frost 2012). It occurs in rocky streams in forested areas, where rocks are typically used as calling sites (Caldart *et al.* 2010). Studies on natural history and ecology of *C. schmidtii* were nonexistent until recently (see Caldart *et al.* 2011; 2012; Bastiani *et al.* 2012), probably because of the lack of knowledge on its distribution. Recent extensions of its distribution indicate a fragmented distribution associated with the southern portion of the Atlantic Forest (Bastiani *et al.* 2012), a severely fragmented and threatened biome (MMA 2003; 2010; SOS Mata Atlântica 2011). Efforts to obtain new occurrence records of *C. schmidtii* are important for the assessment of the threats and conservation status of this species, due to the prospect of an increasing reduction of riparian forests in Brazil as a result of changes in the Brazilian forest code, affecting associated reophilic species (Toledo *et al.* 2010). Moreover, *C. schmidtii* was recently categorized as a threatened species in the Brazilian states of Santa Catarina (CONSEMA, 2011) and Rio Grande do Sul.

The first record of *C. schmidtii* for the Brazilian state of Rio Grande do Sul was based on specimens collected in the Parque Estadual do Turvo, located in the municipality of Derrubadas (Caldart *et al.* 2010). After that, Machado (2012) expanded the species distribution for the municipality of Taquaruçu do Sul, in an area adjacent to the Reserva Indígena do Guarita, without voucher

specimens. So far, these are the only two published records of populations of *C. schmidtii* occurring in the state. In this communication we report the occurrence of *C. schmidtii* for four additional municipalities in the northwestern region of Rio Grande do Sul, compare morphometric data among adult specimens from populations of Misiones, Argentina, Rio Grande do Sul and Paraná, Brazil, through examination of voucher material from herpetological collections, and provide an updated map of the species distribution.

On September 12, 2010, two adult specimens were collected in the municipality of Braga, in a first order stream within an area of highly fragmented mesophytic semideciduous forest, surrounded by an agroecosystem matrix (27°36'4.66" S, 53°47'20.89" W; 377 m altitude). The fragment has an area of about 3.900 m² and is located 1.3 km upstream of the Small Hydroelectric Power Plant (SHP) Marco Baldo (750 m in a straight line), 15.7 km upstream of SHP Toca do Tigre (4.5 km in a straight line), and 11.4 km downstream of SHP Carlos Gonzatto (4.5 km straight line), all located on the Turvo river. In the municipality of Dois Irmãos das Missões, on December 27 and 28, 2011, four specimens, two adults and two juveniles, were collected in a first order stream within the Reserva Biológica Municipal Moreno Fortes (27°36'39.58" S, 53°30'8.91" W, 493 m altitude), a fragment of 458.6 ha of mesophytic semideciduous forest. The remaining records occurred in fragments of mesophytic semideciduous forest in the municipalities of Iraí on March 7, 2012, where we collect a juvenile specimen in a first order stream tributary of the Mel river located within the Reserva Florestal Bosque

Sagrado, a municipal fragment of about 1 ha ($27^{\circ}12'4.62''$ S, $53^{\circ}14'52.94''$ W; 249 m altitude), and in the municipality of Frederico Westphalen on March 12, 2012, where a adult specimen was collected in the Tunas rivulet within the Parque Natural Municipal Arcângelo Busatto, an area of 6.6 ha of preserved forest located within a fragment of approximately 34 ha ($27^{\circ}22'29.39''$ S, $53^{\circ}25'40.71''$ W; 453 m altitude).

These specimens were collected manually, killed with Xylocaine 5%, fixed in 10% formalin, preserved in 80% alcohol (licenses: ICMBio No. 31188-1; IBAMA No 035/2010, reg. 4945131), and deposited in the Herpetological Collection of the Universidade Federal de Santa Maria (ZUFMS 4860-4861, 5265, 5780-5784). The morphological measurements of the adult specimens collected, obtained with a digital caliper (accuracy of 0.01 mm), were compared with measurements of the holotype present in the description of the species (Gallardo 1961) and with those of adult specimens from Misiones, Argentina, Rio Grande do Sul, Brazil, and Paraná, Brazil, obtained from herpetological collections (CFBH, MZUSP, and ZUFMS). In general, morphological measures were similar among populations (Table 1). All specimens presented the diagnostic characteristics of *C. schmidt* according to the description of Gallardo (1961), such as the canthus rostralis less marked, the shorter snout, and a large interorbital distance. Although a high variation in

snout-vent length (22.9-31.8 mm), tibia length (11.9-14.5 mm), and foot length (15.0-21.4 mm) between populations, it may be interpreted as a result of age or sexual differences between specimens, since Gallardo (1961) presented the snout-vent length in adults ranging from 21 to 31.5 mm.

Based on our literature survey and morphological analysis, the distribution of *C. schmidt* may be considered confirmed for 17 localities (Figure 1; Appendix 1). In Paraguay, the species' distribution includes only one locality so far, whereas for Argentina it includes the type locality and two additional locations. Chebez and Casanãs (2000) mentioned additional records related to the species' description (Gallardo 1961) for the northern half of the Misiones province, but did not present geographic coordinates. In Brazil, the species' distribution is currently represented by six localities in the northwestern region of Rio Grande do Sul, three localities in western Santa Catarina, and four localities in Paraná state. For the state of Paraná, Caldart *et al.* (2010) mentioned the occurrence of *C. schmidt* for three localities, including the municipalities of Três Barras do Paraná, within the Parque Estadual Rio Guarani (Segalla *et al.* 2004; P.C.A. Garcia, pers. com.), and the municipalities of Maringá and Porto Camargo. After that, the records mentioned by Caldart *et al.* (2010) for the municipalities of Porto Camargo and Maringá were considered not confirmed by Bastiani *et al.* (2012), since they were based on museum records without examination

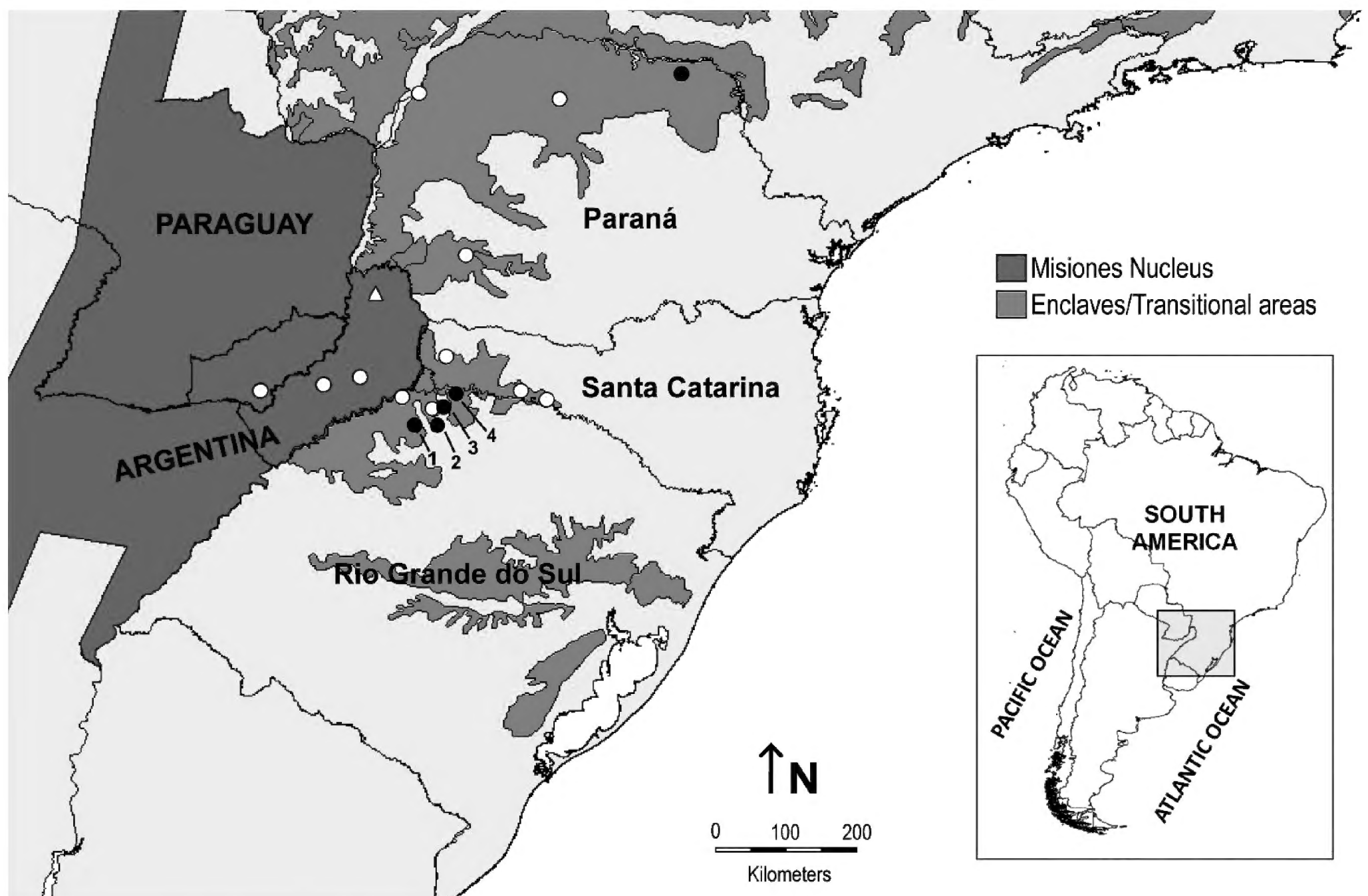


FIGURE 1. Geographical distribution of *Crossodactylus schmidt* associated to Seasonally Dry Tropical Forests of the Misiones Nucleus and Enclaves/Transitional areas (*sensu* Werneck *et al.* 2011). Triangle: type locality, Yacú-poí, Misiones, Argentina. White circles: previously known records of *C. schmidt* (see details of each record in the Appendix 1). Black circles in Rio Grande do Sul, Brazil: new records of *C. schmidt* for the northwestern region of the state: 1 – municipality of Braga ($27^{\circ}36'4.66''$ S, $53^{\circ}47'20.89''$ W); 2 – municipality of Dois Irmãos das Missões ($27^{\circ}36'39.58''$ S, $53^{\circ}30'8.91''$ W); 3 – municipality of Frederico Westphalen ($27^{\circ}22'29.39''$ S, $53^{\circ}25'40.71''$ W); 4 – municipality of Iraí ($27^{\circ}12'4.62''$ S, $53^{\circ}14'52.94''$ W). Black circle in Paraná, Brazil: additional record for the state based on a voucher specimen (CFBH 19842) collected in the municipality of Bandeirantes ($23^{\circ}6'40.28''$ S, $50^{\circ}22'16.90''$ W).

of the material. The record for Porto Camargo mentioned by Caldart *et al.* (2010) derived from specimens collected prior to the description of the species, deposited in the Museu de Zoologia, Universidade de São Paulo (MZUSP 15855-15863) and identified as *C. schmidt* by D. Cochran. Subsequently, part of this material (MZUSP 15855-15856) was exchanged with foreign museums (C. Mello, pers. com.). Recently, we examined the remaining specimens collected in Porto Camargo (MZUSP 15857-15858, 15860-

15863) and the specimens of Maringá (CFBH 17174-17178, 17265) from which we could confirm their identities as *C. schmidt*. In addition, another record for Paraná state was found based on a museum specimen (CFBH 19842), collected in the municipality of Bandeirantes, within the Parque Estadual Mata São Francisco (Table 1). Regarding the historical record of *C. schmidt* in Porto Camargo, collection efforts at this location are important to verify if this population still persists.

TABLE 1. Morphometric comparison (mm) of adults of *Crossodactylus schmidt* from populations of the province of Misiones, Argentina, and the states of Rio Grande do Sul and Paraná, Brazil ¹. Values are presented as mean, followed by standard deviation and range in parenthesis, when available. SVL (snout-vent length); HW (head width); HL (head length); ED (eye diameter); ED/HL (eye diameter-head length ratio); IOD (interorbital distance); IND (internostril distance); END (eye-nostril distance); TD (tympanum diameter); THL (thigh length); TBL (tibia length); FL (foot length).

	Misiones, Argentina		Rio Grande do Sul, Brazil				Paraná, Brazil		
	Holotype (n=1)	San Vicente (n=2)	Derrubadas (n=11)	Dois Irmãos das Missões (n=2)	Braga (n=2)	Frederico Westphalen (n=1)	Porto Camargo (n=4)	Maringá (n=2)	Bandeirantes (n=1)
SVL	29.0	(24.1-24.9)	28.1 ± 2.6 (24.4-31.8)	(27.9-29.2)	(25.1-26.4)	24.7	25.7 ± 1.1 (24.8-27.3)	(22.9-26.5)	28.8
HW	10.0	(8.2-8.8)	8.9 ± 0.7 (8.2-10.2)	(8.5-9.5)	(8.0-9.0)	7.9	9.1 ± 0.9 (8.3-10.4)	(8.6-9.1)	9.4
HL	9.0	(8.7-9.2)	9.1 ± 0.7 (8.0-10.4)	(9.4-9.5)	(8.3-9.0)	8.8	9.4 ± 0.4 (9.0-9.9)	(9.0-9.5)	10.1
ED	4.0	(3.3-3.4)	3.2 ± 0.2 (2.9-3.6)	(3.1-3.1)	(3.2-3.6)	2.4	3.2 ± 0.1 (3.1-3.3)	(3.4-3.5)	4.0
ED/HL	0.44	(0.37-0.38)	0.35 ± 0.02 (0.31-0.39)	(0.33-0.33)	(0.39-0.40)	0.27	0.34 ± 0.01 (0.33-0.35)	(0.33-0.37)	0.39
IOD	4.0	(4.9-5.4)	5.0 ± 0.5 (4.3-5.8)	(4.2-4.3)	(4.3-4.4)	4.7	5.2 ± 0.1 (5.1-5.3)	(5.4-5.6)	6.0
IND	3.5	(2.9-3.1)	2.9 ± 0.3 (2.5-3.4)	(2.9-3.5)	(2.7-3.0)	2.8	3.0 ± 0.1 (2.9-3.2)	(2.8-3.2)	3.5
END	2.5	(1.9-2.0)	2.5 ± 0.3 (2.1-3.0)	(2.3-2.3)	(2.4-2.5)	2.8	2.0 ± 0.2 (1.8-2.2)	(2.1-2.2)	2.1
TD	2.0	(1.6-1.8)	2.3 ± 0.2 (2.0-2.7)	(2.2-2.2)	(2.3-2.4)	2.1	1.8 ± 0.2 (1.5-1.9)	(1.8-1.9)	2.2
THL	12.5	(11.8-12.0)	12.2 ± 0.6 (11.4-13.2)	(11.9-12.5)	(11.7-12.4)	11.1	11.7 ± 0.4 (11.2-12.1)	(12.3-13.5)	13.9
TBL	14.0	(11.9-12.2)	13.0 ± 0.8 (11.9-14.2)	(12.2-12.3)	(12.1-13.2)	12.6	12.9 ± 0.6 (12.1-13.3)	(12.1-13.3)	14.5
FL	15.0	(17.6-18.3)	19.2 ± 1.2 (17.6-21.4)	(17.3-18.1)	(18.3-18.8)	18.5	18.9 ± 0.6 (18.1-19.4)	(18.3-20.0)	21.4

¹ Adult specimens examined, with their respective localities and collection numbers: Holotype (Gallardo, 1961), Yacú-poí, 30 km E of Puerto Libertad: MACN 2943; San Vicente: CFBH 9496-9497; Derrubadas: ZUFMS 4670, 4672, 4675-4678, 4680-4681, 4683, 4689, 4691; Porto Camargo: MZUSP 15857-15858, 15860, 15862; Maringá: CFBH 17176, 17265; Bandeirantes: CFBH 19842.

Overall, the geographical distribution of *C. schmidt* seems to be associated with the Misiones Nucleus of the Seasonally Dry Tropical Forests and its enclaves and transitional areas (*sensu* Werneck *et al.* 2011). Indeed, a recent study has considered *C. schmidt*, along with *Hypsiboas curupi* and *Proceratophrys avelinoi*, as a frog species endemic to the Misiones Nucleus and its transitional areas of Seasonal Forests (Iop *et al.* 2011). Furthermore, for conservation purposes it is important to highlight that the geographical distribution of *C. schmidt* herein proposed is also entirely included within the Alto Paraná Atlantic Forest Ecoregion and its transitional areas with the Araucaria Moist Forest Ecoregion (*sensu* Olson *et al.*, 2001). *Crossodactylus schmidt* is considered as “near threatened” in the Red List of Threatened Species Worldwide (IUCN 2012) because of threats such as the reduction of forests and pollution of soil and water due to agricultural practices (Segalla *et al.* 2004). Results about habitat use suggest that *C. schmidt* is a habitat specialist (Caldart *et al.* 2010; Bastiani *et al.* 2012) and probably sensitive to environmental disturbances (Segalla *et al.* 2004). Bastiani *et al.* (2012) warned of the risk of extirpation of *C. schmidt* in Santa Catarina state, as a result of the progressive reduction of riparian forests in the western region of the state and the absence of populations at sites where it would be likely to occur.

For the state of Rio Grande do Sul, our additional records suggest that the distribution of *C. schmidt* must be greater than currently known. Nevertheless,

the northwestern region of the state suffers similar impacts to those that may be threatening the species in Santa Catarina, i.e., the reduction of forests, expansion of agricultural crops, and hydroelectric power plants. The deforestation of riparian forests may cause critical increase in the water temperature of streams and, therefore, may have a consequent effect on the persistence of species sensitive to high thermal variations. Among 11 species from the subtropical Atlantic Forest of Misiones, Argentina, larvae of reophilic species such as *C. schmidt* and *Hypsiboas curupi* were the most sensitive to thermal variation in water temperature, presenting lower values of upper thermal tolerance (Duarte *et al.* 2011).

Except for the occurrence of *C. schmidt* in the Parque Estadual do Turvo (Caldart *et al.* 2010), in the surroundings of the Reserva Indígena do Guarita (Machado 2012), and in the Reserva Biológica Municipal Moreno Fortes, which have considerable remnants of semideciduous forest, the new records come from fragments located within municipal recreational parks (i.e., Iraí, Frederico Westphalen) or from small fragments in poor conservation condition and strongly affected by human-induced impacts (i.e., Braga). Although our new population records did not expand considerably the geographic distribution of *C. schmidt* in Rio Grande do Sul, we believe they are very opportune because they highlight the importance of conserving these habitats and the need of further studies to verify whether the populations of *C. schmidt* may be declining in these areas, as well as to localize additional populations.

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APPENDIX 1. List of published and collections records of *Crossodactylus schmidt* for Argentina, Paraguay, and for the Brazilian states of Rio Grande do Sul, Santa Catarina, and Paraná, which were used to generate the distribution map, with their respective coordinates and references. The records are listed below from western to eastern locations within their respective countries and states, to facilitate interpretation of the distribution map.

PARAGUAY: Itapúa, near El Tirol, 19,6 km (by road on Route 6) NNE the municipality of Encarnación, 27°10'26.85" S, 55°46'42.10" W (Brusquetti and Lavilla 2006; proximate coordinates, taken from free software Google Earth™). **ARGENTINA:** municipality of Aristóbulo del Valle, Cunã Pirú, Misiones, 27°05'14.52" S, 54°57'1.41" W (Duarte *et al.* 2011); municipality of San Vicente, Depto. Guarany, Misiones, 26°59'42.23" S, 54°29'8.41" W (Caldart *et al.* 2010; based on the voucher specimens CFBH 9495-9498; coordinates from the city proper, taken from free software Google Earth™); Yacú-poí, 30 km E of municipality of Puerto Libertad, Misiones, type locality, 25°55'29.09" S, 54°16'24.90" W (Gallardo 1961; proximate coordinates, taken from free software Google Earth™). **PARANÁ:** municipality of Porto Camargo, 23°22'2.32" S, 53°44'53.90" W (Caldart *et al.* 2010; based on the voucher specimens MZUSP 15857-15858, 15860-15863; coordinates from the city proper, taken from free software Google Earth™); municipality of Três Barras do Paraná, within the Parque Estadual Rio Guarani, 25°25'60" S, 53°7'60" W (Segalla *et al.* 2004; proximate coordinates, taken from free software Google Earth™); municipality of Maringá, at Fazenda Cesumar, 23°25'31.08" S, 51°56'18.96" W (Caldart *et al.* 2010; based on the voucher specimens CFBH 17174-17178, 17265; coordinates from the city proper, taken from free software Google Earth™); municipality of Bandeirantes, within the Parque Estadual Mata São Francisco, 23°6'40.28" S, 50°22'16.90" W (present study, based on the voucher specimen CFBH 19842; coordinates from the city proper, taken from free software Google Earth™). **SANTA CATARINA:** municipality of São Miguel do Oeste, 26°44'41.3" S, 53°23'40.9" W (Lucas and Garcia 2011); municipality of Seara, 27°09'49" S, 52°25'27" W (Lucas and Garcia 2011); municipality of Concórdia, at the Parque Estadual Fritz Plaumann, 27°17'36" S, 52°06'38" W (Bastiani *et al.* 2012). **RIO GRANDE DO SUL:** municipality of Derrubadas, within the Parque Estadual do Turvo, 27°14'34.08" S, 53°57'13.75" W (Caldart *et al.* 2010, based on the voucher specimens ZUFMS 4670, 4672, 4675-4678, 4680-4681, 4683, 4689, 4691); municipality of Braga, 27°36'4.66" S, 53°47'20.89" W (present study, based on the voucher specimens ZUFMS 4860-4861); municipality of Taquaruçu do Sul, near the Reserva Indígena do Guarita, 27°24'53" S, 53°32'59" W (Machado 2012); municipality of Dois Irmãos das Missões, 27°36'39.58" S, 53°30'8.91" W (present study, based on the voucher specimens ZUFMS 5781-5784); municipality of Frederico Westphalen, 27°22'29.39" S, 53°25'40.71" W (present study, based on the voucher specimen ZUFMS 5265); municipality of Iraí, 27°12'4.62" S, 53°14'52.94" W (present study, based on the voucher specimen ZUFMS 5780).